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* Assignment No - 05 *

Q.1| Explain Backward chaining algorithm with help of Example.

→ i| It is generalized Modus ponen backwards to proove query q, and work backwards.

ii| This algorithm uses composition of substitutions. compose ($\theta1, \theta2$) is substitution whose Effect is identical to Effect of applying Each substitution in turn. That is,

SUBST (COMPOSE ($\theta1, \theta2$) = SUBST ($\theta2$, SUBST ($\theta1$, P)).

iii| In this algo, current variable bindings, which are stored in θ, are compond with bindings.

* Procedure :→

- Function : FOL - BC - ASK (KB, goals, θ) return set of substitutions.
- inputs : KB, a knowledge base goals, a list of conjuct Forming a query.
- local variables : answers, a set of substitutions, initially Empty.
  - If goal is Empty then return { θ }.
  - q' ← SUBST (θ, First (goals))
  - For each sentence r in knowledge base where standardize
  - APART (r) = ($P_1 \wedge \dots \wedge P_n \rightarrow q$)

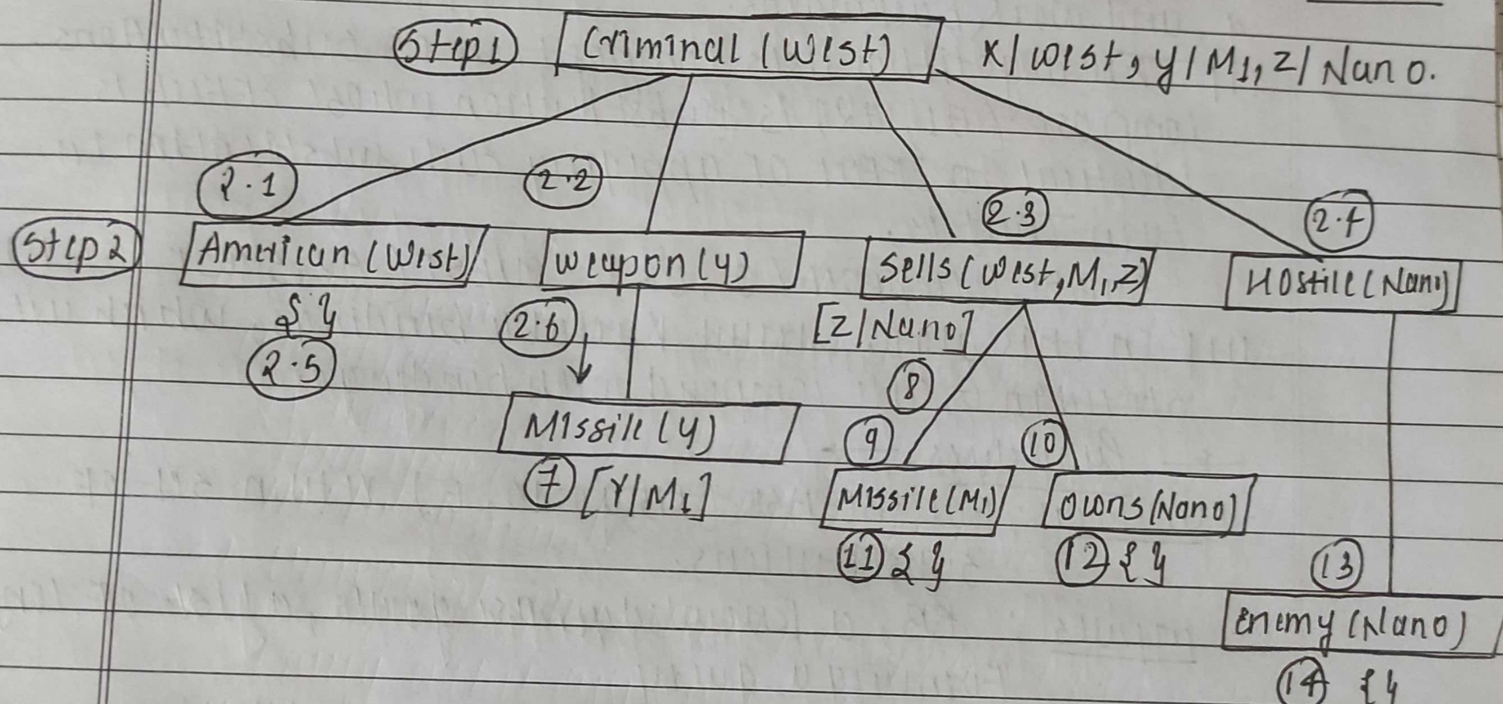
  and θ' ← UNIFY (q, q') succeeds new - goals

  answers ← FOL - BC - ASK (KB, new - goals, COMPOSE (θ', θ)

  U answers

  return answers

* Properties :-
i) It uses depth first search.
ii) It is incomplete due to infinite loops.
iii) It is used for logic programming : Prolog
* Example :-
- Backward chaining to prove that 'West is criminal'



Q.2) Explain :-

→ 1) Unification in FOL :-
1) It is process of finding substitutions for lifted inference rules, which can make different logical expression to look similar.
2) Unification is an procedure for determining substitution needed to make two first order logic expression match.

3] Unification is important component of all first Order logic inference algorithms.
4] The Unification algorithm takes two sentences and returns unifier for them, if one exist.
5] Algorithm statement as follows:-
Unify (P, q) = θ where,
SUBST (θ, P) = SUBST (θ, q)
6] Example: whom does Manmohan meets!
meets(x, mayawati) we rename x as z.
∴ Unify (meets (Manmohan, x) meets (z, Mayawati))
= {x/ Mayawati, z/ Manmohan}

ii] Reasoning with Default Information →
1] This ~~form~~ is very common form of non-monotonic-reasoning. conclusions are drawn based on what is most likely to be true.
2] There are two approaches, both are logic type to default reasoning, one is Non-monotonic logic and other is default logic.

* Default Logic :-
1] Default logic initiates inference rule:

$\frac{A : B}{C}$ where, A is known as prerequisite
B is justification and
C as consequent.

2] Read above inference rule as "If A is consistent with list of what is known to assume that B. Then conclude that C".
3] The rule says that given pre-requisite can be inferred provided its consistent with rest of data.

4) Example → "birds typically fly" represented as,
birds(x) : flies(x) ; which says,
$\overline{\text{flies}(x)}$
"If x is bird and claim that x flies is consistent with we known, then infer that x flies.

3] The idea behind non-monotonic reasoning is to reason with first order logic within first order information.

Q.8] Explain FOL inference for following Quantifiers.

→ 1] Generalization :-

1) If a predicate is true for particular object in the domain, you cannot conclude that it is true for all the objects.

2] However, if predicate is true for an arbitary object, then you can generalize it to be true for all objects in the domain.

3] Universal generalization applies when only x is truely arbitrary, not specific instance.

4] Formal representation :-

If P(x) is true for arbitrary x, then:

$$\underline{P(x) \rightarrow \forall x\, P(x)}$$

5] Example :-

- Given that for an arbitrary x, if x is a number, then x + 0 = x" holds, we can generalize:

$$\forall x\,(x + 0 = x)$$

- This property holds for all numbers.

ii) Existential instantiation :-

1) - This rule states that "For any instance S, variable V and constant symbol K that does not appear else where in KB, following stmt holds,

$$\frac{\exists V, S}{SUBST(\{V/K\}, S)}$$

2) Basically, Existential statement says that there is some object satisfying condition.
3) The instantiation process is just giving name to the object.
4) For Ex → $\exists x$ Crown(x) ∧ OnHead(x, Cindrella)
we can infer sentence,
Crown(H) ∧ OnHead(H, Cindrella) as long as H does Not appear else where in knowledge base.
5) Existential instatiation can be applied once and then ~~Ex~~ existentially quantified sentence can be discarded.

iii) Universal instantiation :- (UI) :-

1) - This rule states that we can infer any sentence obtained by substituting a ground term for the variable.
2) - This rule is described with concept of Substitution.
3) - SUBST(θ, S) denotes result of applying substitution θ to sentence S.
4) With substitution, we can write UI rule as follows :-

$$\frac{\forall v\, S}{SUBST(\{v/g\}, S)}$$, For any variable V, ground term g.

5) UI can be applied many times to produce many different consequences.

6) Ex:- All beautiful Princess are goodhearted.
$\forall x$ Princess (x) $\wedge$ Beautiful(x) $\rightarrow$ Goodhearted (x).

iv) <u>Universal</u> <u>Instantiation</u> :-

1) If a property is true for all elements in the domain, then it must be true for any particular instance of that domain.
2) <u>Universal Instantiation</u> is commonly used in proofs where general rule is applied to specific cases.
3) <u>Formal</u> representation :$\longrightarrow$
- If $\forall x P(x)$ is true, then for any specific object c in that domain. <u>P(c)</u>
4) <u>Example</u>:-
Given, $\forall x\ (x \geq 0 \rightarrow x^2 \geq 0)$
we can instantiate for specific value say $x = 5$:
$5 \geq 0 \rightarrow 5^2 \geq 0$
which simplifies <u>$25 \geq 0$</u>
$\therefore$ This confirms property holds for that particular instance.

Q.4) Explain the Unification algorithm in FOL. Solve step wise with proper comments if P(x, g(x)) is Equal to or not Equal to P(prime, f(prime)).

$\rightarrow$ 1) Unification is process for determining substitutions needed to make two first order logic expressions match.

2) The Unification algorithm is process in FOL used to determine whether two Expressions can be made Identical by substituting variables with terms.

3) If its possible, it finds the most general unifier, which is simplest set of substitutions that makes Expressions identical.

4) It is used in Automated Reasoning, logic programming and theorem proving to determine when two logic Expressions can be made identical finding substitution of variable with terms.

5) If such substitution Exists, then its called Most general unifier.

6) P(x, g(x)) and F(prime, F(prime)) can be defined as follows:-

Step 1 :- Identify Main function symbols.
- 1st Expression :- P(x, g(x))
- 2nd Expression :- F(prime, F(prime))
- Outermost Function symbols are → P and F.

Step 2 :- Check if function Symbols Match.
- In FOL, two terms can only unify if their Outermost Function symbols are same.
- Here P ≠ F; Meaning Function symbols are different.

Step 3 :- Determine if unification is possible.
- Since, P and F are different, No Substitution can make two Expressions Identical.

Step 4 :- conclusion

- function symbols are different at highest level, No further step are needed.
- Two Expression cannot be unified.
- Final answer :- $p(u, g(u)) \neq f(prime, f(prime))$